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ABSTRACT

This project description is designed to show how graphing calculators and calculator-based laboratories (CBLs) can be used to explore topics in physics and health sciences. The activities address such topics as respiration, heart rate, and the circulatory system. Teaching notes and calculator instructions are included as are blackline masters. (MM)

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ED 464 808

# BE STILL MY HEART

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Columbus, OH
March 16 – 18, 2001

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# BE STILL MY HEART

## INTRODUCTION:

Quality of life is tied in to how we "feel". Are we often tired? Are we winded after a brief period of exercise? Does stress affect us? Do we feel faint at times? The efficiency of our heart has much to do with how we feel. Also, the capacity to breathe in different situations will affect our well being.

In this project, you will look at various aspects of the circulatory and respiratory systems. You will consider the heart rate at rest and the active heart rate. You will look at the EKG reading and the respiratory rate. You then will determine how these systems of our body interrelate and affect each other.

In your teams, you will decide on a specific project that will compare and contrast these physical aspects of different populations. A scientific paper describing your project, as well as, a PowerPoint presentation of your results will then be turned in to conclude your research.

## EQUIPMENT AND METHODS:

The following list of equipment will be used to aid you in your experimentation:

- TI-83 Plus Calculator
- TI Graph Link
- CBL 2
- Respiration Monitor Belt
- Heart Rate Monitor
- Exercise Heart Rate Monitor
- EKG Sensor
- Biology Gas Pressure Sensor
- Computer

You will use the scientific method in developing your experiment. Proper procedures for collecting data, graphical analysis, and appropriate discussions should prepare you to develop an hypothesis that can be tested. Every group member needs to have a clear understanding of the experiment. Factors that might affect your data include: gender, age, exercise, baroreceptor reflex, caffeine consumption, eating, time of day, etc.

**SYLLABUS:**

| DATE | TOPIC |
|---|---|
| Nov. 7 | Side by Side Interviews & Team Building Activity |
| Nov. 8 | Introduction of Project & Technology |
| Nov. 14 | Respiratory System & Lab |
| Nov. 15 | Respiratory System Continued |
| Nov. 28 | Introduction to Respiration Monitor Belt |
| Nov. 29 | Respiration Monitor Belt Activity |
| Dec. 5 | Circulatory System & Lab |
| Dec. 6 | Circulatory system Continued |
| Dec. 12 | Introduction to Heart Rate Monitors |
| Dec. 13 | Heart Rate Monitor Activity |
| Dec. 19 | Introduction to EKG Sensors |
| Dec. 20 | EKG Sensor Activity |
| Jan. 9 | Guest Speaker |
| Jan. 10 | Field Trip |
| Jan. 16 | Introduction to Scientific Method |
| Jan. 17 | Development of Research Question, Hypothesis, & Experiment |
| Jan. 23 | Experimentation |
| Jan. 24 | Experimentation |
| Jan. 30 | Results & Conclusions (Computer Lab) |
| Jan. 31 | Results & Conclusions (Computer Lab) |
| Feb. 6 | Results & Conclusions (Computer Lab) |
| Feb. 7 | Results & Conclusions (Computer Lab) |
| Feb. 13 | Papers Due & Presentations |
| Feb. 14 | Finish Presentations |

**** All dates are tentative and may be changed at the discretion of the instructors!!***

**TEACHER COMMENTS:**

A successful project will require the cooperation of **all** members of the **team**. Each member should assume different responsibilities, i.e. data organizer, data gatherer, time manager, data recorder, technology expert, typist, etc.

As a team you will be responsible for developing an *hypothesis* about a specific *variable* that will be experimentally tested. In order to have a good hypothesis the team will need to brainstorm, talk to knowledgeable people, and do outside research.

**Remember the common saying: "There is no 'I' in team".**

**EVALUATION:**

The grade for the project will be a combination of teamwork evaluation, written research paper, power point presentation, and individual work evaluation. It is important as a member of your cooperative team to make sure that your deadlines are met, regardless of any absences on your part. ***Your attendance is important for the completion of this project.***

This project will count as a **major** part of your quarterly grade, therefore it should **not** be taken lightly. The instructors will be continually monitoring each individual's active participation in the project.

We, as instructors, are very excited to implement this project into our curriculum. This has been specifically designed with you in mind. At the end of this project we will be asking for your evaluative input. We hope this will be a positive and rewarding experience for everyone involved!

# FIXING THE LEANING TOWER OF PISA

## BACKGROUND:

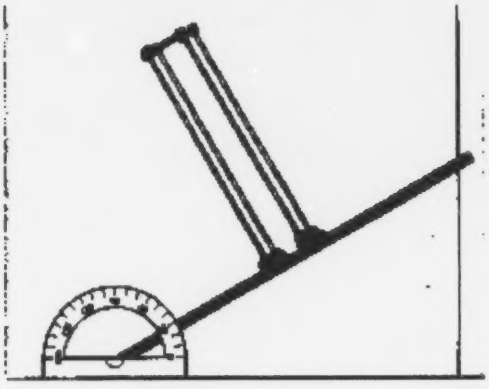
Despite a 10° tilt, the Leaning Tower of Pisa has been standing for over 800 years. But Italy's most famous tourist attraction still needs serious propping up. The tower is the site of what may have been the first true scientific experiment, conducted by Galileo Galilei in the 16th century.

Engineers and scientists are on a mission to prevent the Leaning Tower of Pisa from toppling. But instead of straightening the tower, they hope to preserve its celebrated tilt. When engineers study problematic situations such as the tilt of the Pisa tower, they often construct physical models. Here's your chance to build your own tower and measure its maximum tilt before it topples.

## CHALLENGE:

Build a tower using only straws and modeling clay on a piece of heavy stock cardboard that serves as a base. (The tower shown in the diagram is only one example.) Raise one end of the cardboard base so that the tower tilts by 10 degrees. Measure the angle with a protractor. Wait 30 seconds, and then record any change in the tower's appearance.

Increase the base tilt by another 10 degrees. Wait 30 seconds, and then record any change in the tower's appearance. Continue increasing the tilt angle by ten-degree increments, until the tower topples.



## MATERIALS:

- Straws
- Modeling clay
- Scissors
- Heavy stock cardboard
- Protractor

## THE RESPIRATION MONITOR BELT

### YOU NEED:

1 CBL 2 Unit
1 TI-83 Plus Graphing Calculator
1 Unit-to-Unit Link
1 Respiration Monitor Belt
1 Biology Gas Pressure Sensor
1 CBL-DIN Adapter
ChemBio PRGM
TI Graph Link

### INSTRUCTIONS:

- Snugly wrap the belt around the diaphragm of the test subject, so the bladder and tubes are on his or her front side. The center of the Respiration Monitor Belt should be lined up with the test subject's elbows, as shown in the figure. The top edge of the monitor belt will be over the diaphragm of the person being tested. Press the Velcro strips together at the back.

- Have the test subject sit on a chair near the CBL 2. Attach the Respiration Monitor Belt to the Biology Gas Pressure Sensor. To do this, locate the white luer lock connector at the end of one of the two pieces of tubing that come out of the bladder (the one without the bulb). Attach the white connector to one of the stems of the 3-way valve of the Biology Gas Pressure Sensor with a gentle half turn.

- Connect the Biology Gas Pressure Sensor to the CBL-Din Adapter.

- Connect the CBL-Din Adapter to Channel 1 of the CBL 2 System.

- Connect the CBL 2 System to the TI-83 Plus Graphing Calculator using the Unit-to-Unit Link.

- Close the bladder to the outside atmosphere by turning the blue "off" handle of the 3-way valve so it is aligned with the stem leading to the outside atmosphere. Close the shut-off screw of the bulb pump by turning it clockwise as far as it will go.

- Pump air into the bladder using the bulb pump. At this point the belt and bladder should press firmly against the test subject's diaphragm.
- Once normal breathing of the test subject results you are ready to begin doing the experiment.
- Start the TI-83 Plus Graphing Calculator data collection program using the following keying sequence:
  - **APPS**
  - **3:ChemBio**
  - **ENTER**
  - **ENTER**
  - **1:SET UP PROBES**
  - **ENTER**
  - **NUMBER OF PROBES = 1**
  - **ENTER**
  - **7:MORE PROBES**
  - **ENTER**
  - **7:MORE PROBES**
  - **ENTER**
  - **4:RESPIR. BELT**
  - **ENTER**
  - **CHANNEL NUMBER IS 1**
  - **ENTER**
  - **1:USE STORED**
  - **ENTER**
  - **2:COLLECT DATA**
  - **ENTER**
  - **2:TIME GRAPH**
  - **ENTER**
  - **TIME BETWEEN SAMPLES IN SECONDS IS 1**
  - **ENTER**
  - **NUMBER OF SAMPLES IS 60**
  - **ENTER**
  - **ENTER**
  - **1:USE TIME SETUP**
  - **ENTER**
  - **Y-min = 700**
  - **ENTER**
  - **Y-max = 900**
  - **ENTER**
  - **Yscl = 10**
  - **ENTER**
  - **ENTER**

## **EXPERIMENT #1:** *Respiration Rate at Rest*

You can study respiration patterns and examine how certain stimuli and conditions affect those patterns. It is very important that the test subject be positioned so he or she cannot directly view the calculator screen. Once the test subject is breathing in a relaxed manner, begin collecting data.

Once you are satisfied with your graph, then do the following:

- Save your data as a program
- Print the resulting graph using appropriate labels and title
- Determine your respiration rate and respiration period

1. Respiration Rate = $\frac{\textit{Number of Breaths}}{\textit{Number of Seconds}}$

   a.) What is the reading, in seconds, of your first selected peak? (NOTE: the *x*-value represents time in seconds.)

   b.) What is the reading, in seconds, of the second selected peak?

   c.) Subtract answer *a* from answer *b* and record the result.

   d.) Determine the number of completed breaths in your reading from above. (NOTE: peak-to-peak = 1 breath) Number of breaths is equal to: _____

   e.) Use the following procedure to determine your respiration rate.

      1.) To calculate the number of breaths per second, divide answer *d* by answer *c* and record your answer.

      2.) To determine your respiration rate, (breaths/minute), multiply your answer above by 60 and record the result.

2. To determine your Respiration Period divide answer *c* by answer *d* and record your result.

   Respiration Period = $\frac{\textit{Number of seconds}}{\textit{Number of Breaths}}$

3. Compare your Respiration Rate to others in your group. Discuss the factors that you think might affect different rates.

## **EXPERIMENT #2:** *Respiration Rate Interrupted by Holding of Breath*

- In this experiment, the test subject is instructed to breathe in a relaxed manner for 20 seconds, hold his or her breath for 40 seconds, and then resume breathing for 20 seconds. (NOTE: **NUMBER OF SAMPLES IS 80** in the calculator set up.)

Once you are satisfied with your graph, then do the following:

- Save your data as a program
- Print the resulting graph using appropriate labels and title
- Determine your respiration rate and respiration period after holding your breath

1. Determine the length of time you held your breath

   a.) What is the reading, in seconds, when you started to hold your breath? (NOTE: the *x*-value represents time in seconds.)

   b.) What is the reading, in seconds, when you began breathing?

   c.) Subtract answer *a* from *b* to determine the length of time you held your breath.

2. Respiration Rate = $\frac{\textit{Number of Breaths}}{\textit{Number of Seconds}}$

   a.) What is the reading, in seconds, of your first selected peak? (NOTE: the *x*-value represents time in seconds.)

   b.) What is the reading, in seconds, of the second selected peak?

   c.) Subtract answer *a* from answer *b* and record the result.

   d.) Determine the number of completed breathes in your reading from above. (NOTE: peak-to-peak = 1 breath) Number of breaths is equal to:

   _____

   e.) Use the following procedure to determine your respiration rate.

      1.) To calculate the number of breaths per second, divide answer *d* by answer *c* and record your answer.

      2.) To determine your respiration rate, (breaths/minute), multiply your answer above by 60 and record the result.

3. To determine your Respiration Period divide answer *c* by answer *d* and record your result.

   Respiration Period = $\frac{\textit{Number of seconds}}{\textit{Number of Breaths}}$

4. Compare your "breath holding time" to those in your group. What factors could affect the time a person could hold their breath?

## QUESTIONS:

1. What does the maximum (top of a peak) in your graph represent?
2. What does the minimum in your graph represent?
3. How do you think the graph of your respiration rate would change after 2 minutes of rigorous exercise?
4. Give a description of what happened to your respiration rate after you held your breath for 40 seconds?

## HEART RATE MONITOR

### INTRODUCTION

This sensor monitors a person's heartbeat. Unlike an electrocardiograph (EKG), which monitors the electrical signal of the heart, this sensor monitors the flow of blood through the ear lobe. As the heart forces blood through the blood vessels in the ear lobe, the amount of blood in the ear changes with time. This sensor shines a light through the ear lobe and measures the light that is transmitted. The clip can also be used on a fingertip or on the web of skin between your thumb and index finger. By graphing this signal, the heart rate can be determined.

### YOU NEED

1 CBL 2 Unit
1 TI-83 Plus Graphing Calculator
1 Unit-to-Unit Link
1 CBL-DIN Adapter
1 Heart Rate Monitor
ChemBio PRGM

### INSTRUCTIONS

- Connect the CBL 2 System to the TI-83 Plus Graphing Calculator using the Unit-to-Unit Link.
- Connect the Heart Rate Monitor to the CBL-DIN Adapter.
- Connect the CBL-Din Adapter to Channel 1 of the CBL 2 System.
- Connect the Heart Rate Monitor clip on your ear lobe.

- Start the TI-83 Plus Graphing Calculator data collection program using the following keying sequence:

- **APPS**
- **3:ChemBio**
- **ENTER**
- **ENTER**
- **1:SET UP PROBES**
- **ENTER**
- **NUMBER OF PROBES = 1**
- **ENTER**
- **7:MORE PROBES**
- **ENTER**
- **6:HEART RATE**
- **ENTER**
- **ENTER**
- **1:EAR CLIP**
- **ENTER**
- **1:COLLECT DATA**
- **ENTER**

- **Note:** This program allows you to display the heart rate on the screen, graph the data, then repeat the process, if you wish. If you do not get good values, or if it says, "No beats found" several times, try adjusting the position of the ear clip.

## EXPERIMENT

Check for *baroreceptor reflex*; that is, changes in heart rate for a person when reclined, sitting, and standing caused by the need for the heart to pump blood to different levels.

1. Each person should find their heart rate in beats per minute (bpm) when reclined, sitting, and standing.

2. Collect data a total of three times for each position and then compute your average heart rate in bpm.

3. Record your heart rate in bpm after each trial.

4. Record the average heart rates for each position.

## QUESTIONS

1. What position gives the fastest heart beat? Why?

2. What position gives the slowest heart beat? Why?

## EXERCISE HEART RATE MONITOR

### INTRODUCTION

The Exercise Heart Rate Monitor monitors a person's heartbeat. Similar to an electrocardiograph (EKG), this sensor monitors the electrical signal of the heart. Each time the heart beats, an electrical signal is generated. This signal is measured at the surface of the skin by electrodes imbedded in the chest belt of the Exercise Heart Rate Monitor. By graphing this signal, the heart rate can be determined. The Exercise Heart Rate Monitor consists of a transmitter belt, plug-in receiver, and a large and small elastic strap. The transmitter belt is worn just below the chest and held in place by an elastic strap. The plug-in receiver connects to the CBL. The reception range of the plug-in receiver is 80-100 cm or about 3 feet.

### YOU NEED

1 CBL 2 Unit
1 TI-83 Plus Graphing Calculator
1 Unit-to-Unit Link
1 CBL-DIN Adapter
1 Exercise Heart Rate Monitor
3 drops saline solution
ChemBio PRGM

### INSTRUCTIONS

- Connect the CBL 2 System to the TI-83 Plus Graphing Calculator using the Unit-to-Unit Link.
- Connect the Exercise Heart Rate Monitor to the CBL-DIN Adapter.

- Connect the CBL-DIN Adapter to Channel 1 of the CBL 2 System.

- Depending on your size, select a small or large elastic strap. Secure one of the plastic ends of the elastic strap to the transmitter belt of the Exercise Heart Rate Monitor. It is important that the strap provide a snug fit of the transmitter belt.

- Wet each of the electrodes (the two grooved rectangular areas on the underside of the transmitter belt) with 3 drops of saline solution.

- Secure the transmitter belt against the skin directly over the base of the rib cage. The POLAR logo on the front of the belt should be in line with the chest center. Adjust the elastic strap for a tight fit.

- Place the receiver in the right hand. Remember that the receiver must be within 80 cm (3 ft.) of the transmitter belt.

- Start the TI-83 Plus Graphing Calculator data collection program using the following keying sequence:

- **APPS**
- **3:ChemBio**
- **ENTER**
- **ENTER**
- **1:SET UP PROBES**
- **ENTER**
- **NUMBER OF PROBES = 1**
- **ENTER**
- **7:MORE PROBES**
- **ENTER**
- **6:HEART RATE**
- **ENTER**
- **ENTER**

- **2:CHEST BELT**
- **ENTER**
- **1:COLLECT DATA**
- **ENTER**
- **1:EVERY 5 SEC.**
- **ENTER**

**EXPERIMENT**

In this experiment, you will check a person's heart rate before and after a short period of vigorous activity.

1. One member of the team will be the subject while the other members observe and record the data. Team members will then switch roles and repeat the experiment.

2. Collect data and record the resting heart rate in beats per minute (bpm) for the subject.

3. The subject should exercise vigorously for 2 minutes and then data on the active heart rate should be collected and recorded.

4. Data should be collected for more than one trial for each subject.

**QUESTIONS**

1. The average heart rate, in a resting position, is 70 to 80 beats per minute. How did your "resting heart rate" compare?

2. What human factors might explain a small increase from the "resting" heart rate to the "active" heart rate?

3. What human factors might explain a large increase from the "resting" heart rate to the "active" heart rate?

# EKG

## INTRODUCTION

The electrocardiogram (EKG) is a graphic tracing of the hearts' electrical activity. A typical tracing consists of a series of waveforms occurring in a repetitive order. These waveforms arise from a flat baseline called the *isoelectric line*. Any deflection from the isoelectric line denotes electrical activity.

The letters P, Q, R, S, and T designates the five major deflections on a normal EKG. One heart cycle is represented by a group of waveforms beginning with the P wave, followed by the QRS wave complex, and ending with the T wave.

The P wave represents the depolarization of the atria and is associated with their contraction. The QRS wave complex consists of three waves. The first negative deflection is the Q wave and is followed by a positive deflection called the R wave. The complex ends with a negative deflection known as the S wave. The QRS wave complex denotes depolarization of the ventricles and is associated with their contraction. Atrial repolarization occurs during the depolarization of the ventricles. For this reason, the waveform associated with atrial repolarization is undetectable on and EKG. The last wave is called the T wave, and is usually represented by a positive deflection. The T wave indicates ventricular repolarization.

Electrical energy is also generated by skeletal muscle, and can be seen as muscle artifacts if your arm is moved while the EKG is attached. The sequence from P wave to T wave represents one heart cycle. The number of cycles in a minute is called the *heart rate* and is typically 70-80 beats per minute at rest.
Some typical times for portions of the EKG are:

| | |
|---|---|
| P-R interval | 0.12 to0.20 seconds |
| QRS interval | less than 0.1 seconds |
| Q-T interval | less than 0.38 seconds |

If your EKG does not correspond to the above numbers, DO NOT BE ALARMED! These numbers represent typical averages and many healthy hearts have data that fall outside of these parameters. To read an EKG effectively takes considerable training and skill. This sensor is NOT intended for medical diagnoses.

**YOU NEED**

1 CBL 2 Unit
1 TI-83 Plus Graphing Calculator
1 Unit-to-Unit Link
1 CBL-DIN Adapter
1 EKG Sensor
3 Resting ECG Electrodes
ChemBio PRGM

**INSTRUCTIONS**

- Connect the CBL 2 System to the TI-83 Plus Graphing Calculator using the Unit-to-Unit Link.
- Connect the EKG Sensor to the CBL-DIN Adapter.
- Connect the CBL-DIN Adapter to Channel 1 of the CBL 2 System.
- Use three electrode patches per subject. The electrodes can be reused, but they tend to absorb moisture (they are very hygroscopic) and, therefore, reuse is not recommended.

  **Note: Once opened, the electrodes should be kept refrigerated in a clean, dry, airtight storage, opened electrode packages cannot be stored from one year to the next.**

- Because the electrical signal produced by the heart and detected at the body's surface is so small, it is very important that the electrode patch makes good contact with the skin. Scrub the areas of skin where the patches will be attached with a paper towel to remove dead skin and oil.

- Peel three electrode patches from the backing paper. Firmly place the first electrode on the right wrist.

- Place a second electrode on the inside of the right elbow.

- Place a third electrode on the inside of the left elbow.

- Place each electrode so it is on the inside part of the arm (closer to the body) and the tab on the edge of the electrode patch points down. This way, the wire of the sensor can hang freely without twisting the edge of the electrode patch.

- Connect the micro alligator clips from the sensor to the tabs on the edges of the electrode patches.

- Connect the black (or "reference") alligator clip to the right wrist electrode patch. This is the reference point for the isoelectric line (baseline).

- Connect the green (or negative) alligator clip to the right elbow electrode patch.

- Connect the red (or positive) alligator clip to the left elbow electrode patch.

- Start the TI-83 Plus Graphing Calculator data collection program using the following keying sequence:

- **APPS**
- **3:ChemBio**
- **ENTER**
- **ENTER**
- **1:SET UP PROBES**
- **ENTER**
- **NUMBER OF PROBES = 1**
- **ENTER**
- **7:MORE PROBES**
- **ENTER**
- **7:MORE PROBES**
- **ENTER**
- **5:EKG**
- **ENTER**
- **ENTER**
- **1:COLLECT DATA**
- **ENTER**

**EXPERIMENT #1:** *Resting EKG*

- Record the EKG of a person who is at rest. The person whose EKG is being recorded should remain calm and relaxed. Encourage the person to breathe normally.

- To complete the experiment, access the **FOCUS** program. Select one complete PQRST wave, selecting a value to the left of P and to the right of T. These values, from P to T will be transferred to $L_3$ and $L_4$ and then graphed. Use this graph, not the original, to answer most of the questions in Experiment #1. When you need to view the original graph, turn Plot 2 off and Plot 1 on.

- Complete the questionnaire for Experiment #1.

**EXPERIMENT #2:** *EKG After Mild Exercise*

- Using the EKG Sensor, record and EKG of a person who is initially at rest. Disconnect the sensor wires from the electrode patches, but leave the patches on the person being monitored. Have the person exercise for two minutes by jogging in place or by "stepping in time." Reattach the sensor wires to the electrodes on the person when they have finished exercise and record a new EKG.

- To complete the experiment, access the **FOCUS** program. Select one complete PQRST wave, selecting a value to the left of P and to the right of T. these values, from P to T will be transferred to $L_3$ and $L_4$ and then graphed. Use this graph, not the original, to answer most of the questions in Experiment #2. When you need to view the original graph, turn Plot 2 off and Plot 1 on.

- Complete the questionnaire for Experiment #2.

NAME _____ DATE _____ PERIOD _____

**BE STILL MY HEART**
**EKG SENSOR EXPERIMENT #1 – ANSWER SHEET**

1. Determine, in seconds, the length of the PR interval.

2. Determine, in seconds, the length of the QRS interval.

3. Determine, in seconds, the length of the QT interval.

   *Some typical times for portions of the EKG are:*

| | |
|---|---|
| *PR interval* | *0.12 to 0.20 seconds* |
| *QRS interval* | *Less than 0.1 seconds* |
| *QT interval* | *Less than 0.38 seconds* |

4. How does your interval reading compare to the typical times?
   a. The PR interval?
   b. The QRS interval?
   c. The QT interval?

5. The sequence from the P wave to the T wave represents one complete heart cycle. Find, in seconds, the length of one complete heart cycle.

6. Each heart cycle is followed by a flat "isoelectric line" of no apparent heart activity. Determine, in seconds, the length of one P wave to the next P wave.

7. To determine your heart rate in beats per minute divide 60 seconds by your answer in number #6.

8. A typical heart rate for a person at rest is 70 – 80 beats per minute how does your heart rate compare?

9. Why do you think that your heart rate at rest may not be in the typical range?

**NAME** _____ **DATE** _____ **PERIOD** _____

**BE STILL MY HEART**
**EKG SENSOR EXPERIMENT #2 – ANSWER SHEET**

1. Determine, in seconds, the length of the PR interval.

2. Determine, in seconds, the length of the QRS interval.

3. Determine, in seconds, the length of the QT interval.

4. How does your interval reading compare to those in Experiment #1?
   a. The PR interval
   b. The QRS interval
   c. The QT interval

5. The sequence for m the P wave to the T wave represents one complete heart cycle. Find, in seconds, the length of one complete heart cycle.

6. A flat "isoelectric line" of no apparent heart activity follows each heart cycle. Determine, in seconds, the length from one P wave to the next P wave._____What does this length represent?

7. Determine, by dividing by 60 seconds by your answer in number #6, the number of heartbeats you would have in one minute. This is called your heart rate.

8. How does this interval compare to the rate in Experiment #1?

Name _____ Date _____ Period _____

**BE STILL MY HEART**
**FINAL PROJECT RUBRIC**

**WRITTEN**

TITLE PAGE (3 points)

_____ / 3 Three parts to the title

INTRODUCTION (25 points)

_____ / 5 Problem / Purpose stated in correct form

_____ / 10 Appropriate background information is given

_____ / 5 All information is tied together in a clear and concise manner

_____ / 5 Hypothesis is stated in correct form

METHODS AND MATERIALS (30 points)

_____ / 5 Clear enough, any reader could duplicate the experiment

_____ / 15 Specific method of gathering data is given

_____ / 10 Control and variable set up explained thoroughly

RESULTS (24 points)

_____ / 8 At least 2 appropriate graphs and 2 appropriate tables present

_____ / 4 All graphs and tables are labeled appropriately (titles, axes, etc.)

_____ / 4 All graphs and tables are numbered appropriately

_____ / 8 An explanation is given for each graph and table in an objective manner

DISCUSSION (30 points)

_____ / 5 Clear conclusions have been reached with reference to the hypothesis

_____ / 5 Ideas supported with data values or results from tables and graphs

_____ / 15 Patterns, correlations, and relationships are discussed

_____ / 5 Significance and importance of findings are discussed

CONCLUSIONS (10 points)

_____ / 5 An appropriate summary of the conclusions is present

_____ / 5 Further investigations suggested

GRAMMAR, SPELLING, ETC. (10 points)

_____ / 5 Paper is free of grammatical, spelling, and punctuation errors

_____ / 5 All section headings are present

COMMENTS:

**POWER POINT PRESENTATION**

TITLE (1 slide)

_____ / 4 Appropriate title of the experiment is given

INTRODUCTION (1 – 2 slides)

_____ / 4 Purpose and Hypothesis stated

MATERIALS AND METHODS (2 – 4 slides)

_____ / 8 At least 2 pictures of the experimental designs are in the presentation

_____ / 8 At least 2 action pictures of the experiment are in the presentation

RESULTS (2 – 4 slides)

_____ / 16 At least 2 graphs and 2 tables of data present

CONCLUSION (1 slide)

_____ / 4 A conclusion summary of the experimental results is present

CREATIVITY

_____ / 4

PRESENTATION QUALITY

_____ / 10

PRESENTATION PARTICIPATION

_____ / 20 Student actively participated in the presentation of the project

PEER EVALUATION

_____ / 20

EXTRA CREDIT

_____

FINAL GRADE

_____ / 230 TOTAL - number of points earned for written and power point